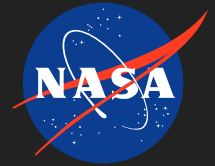


Operational Ground Testing Protocol to Optimize Astronaut Sleep Medication Efficacy and Individual Effects

Completed Technology Project (2010 - 2015)



Project Introduction

The NASA Johnson Space Center (JSC) Behavioral Health and Performance (BHP) Element of Space Medicine Division, Human Research Program (HRP) is supporting this ground-based directed research study to evaluate the effects of sleep medications (relative to placebo) on astronaut cognitive performance after an abrupt awakening. The second objective of the study is to develop a protocol to select a sleep medication and dose that minimally affects an individual's cognitive performance upon awakening. Following completion of the study, it is the intent of the BHP Element to work with Space Medicine in the transition of the data and protocol as "best practices" for medical operations provided by the Clinical Services Branch in the Space Medicine Division at the NASA Johnson Space Center. Evidence indicates that astronauts in the Shuttle environment sleep about 6 hours a night on average. Sleep is also markedly reduced during pre-flight training. It is therefore not surprising that sleep medications serve as a primary mitigation strategy during spaceflight missions. Recent data indicate that, in some cases, crewmembers note taking medications twice in one night. The sleep medications used in spaceflight are Food & Drug Administration (FDA) approved for sleep periods of 8 hours or more, but they have not been studied for their effects on waking cognitive functions during an alarm-based awakening from sleep (under 8 hours) that has occurred in spaceflight numerous times. There is a need to identify the cognitive effects of sleep medications during such premature awakenings, and to identify the sleep medications (and dosages) that produce the fewest cognitive effects and adverse reactions in individual astronauts. Consequently, the proposed study aims to characterize the effects of the most commonly used sleep medications and dosages on performance after an unplanned awakening, while providing the foundation for future development of individualized protocols for sleep medication use during training and on-orbit. Findings from the study will also further inform BHP's development of an education training program related to countermeasures for sleep loss, circadian desynchronization, fatigue, and work overload for astronauts as well as ground crews who work night shifts in support of missions. Results of the study will also inform the human system health and medical standards and requirements for future exploration missions.

The study protocol was successfully pilot tested with N=7 subjects (6 NASA flight surgeons and 1 BHP Operations professional) as subjects from March through June, 2009. The pilot study results supported the scientific feasibility of conducting a randomized, blinded, placebo controlled study of sleep medication effects on simulated alarm-based awakenings. Preliminary analysis from the pilot study indicated differences in performance upon abrupt awakening between the sleep medication and placebo conditions. Thus, the pilot data also support the likelihood of new scientific and clinical insights from the proposed Phase II studies with NASA astronauts.

In Phase II, two randomized, blinded, placebo-controlled, cross-over trials will be conducted. Zolpidem (Ambien) is the most commonly, and Zaleplon



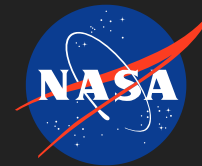
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(Sonata) is the second most commonly used sleep aid medication used in spaceflight. In Phase II, the hypnotic medication and the placebo will be indistinguishable by subjects. Experiment 1 will involve N=14 subjects randomized to placebo, 10 mg zolpidem, and 10 mg zaleplon in counterbalanced order. Those astronauts who have had a previous adverse experience with 10 mg zolpidem will be empanelled into Experiment 2, which will involve N=20 subjects randomized to placebo, 5 mg zolpidem, and 10 mg zaleplon. If there are astronauts who have had a previous adverse experience with 10 mg zaleplon, a third experiment will be proposed that involves placebo, 10 mg zolpidem, and 5 mg zaleplon. The primary study aim is to determine whether there is a significant negative effect on cognitive performance at abrupt awakening from sleep medications at different dosages. The secondary study aim is to develop the basis for a practical, individualized ground-based protocol that will be useful in evaluating, for each individual astronaut, the percentage of performance change as well as other qualitative effects produced by commonly used sleep medications in spaceflight. Data acquisition for both experiments occurs in the Astronaut Quarantine Facility (AQF) at JSC and was initiated February 2012. Experimental methods and cognitive outcomes are the same as those used in the pilot investigation.

Anticipated Benefits

The 3-minute Psychomotor Vigilance Test (PVT) Self Test (PST) used in the NASA Extreme Environment Mission Operations (NEEMO) 14 and Desert Research and Technology Study (DRATS) analogs, as well as on the International Space Station (ISS), is being developed to help people quickly and objectively detect the extent to which fatigue is affecting their alertness and reaction times. As such, the technology has high potential for usefulness in a range of safety-sensitive environments on Earth. Potentially any occupation in which alertness and fatigue management are essential to prevent errors on critical tasks will benefit from adaptations of the PVT Self Test technology (e.g., airport security screeners, physicians on night shifts and prolonged call). The other two brief cognitive tests evaluated in this project—the Digit Symbol Substitution Test (DSST) and Descending Subtraction Test (DST)—are well validated in the laboratory to be measures of cognitive throughput (DSST) and working memory (DST). These tests have potential to be useful in a range of Earth-based scenarios in which cognitive capability must be rapidly assessed (e.g., sedation, mild to moderate traumatic brain injury, mild cognitive impairment with aging).

Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Project Manager:

Lauren B Leveton

Principal Investigator:

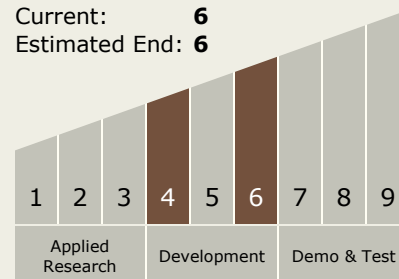
Smith L Johnston

Co-Investigator:

David F Dinges

Technology Maturity (TRL)

Start: 4
Current: 6
Estimated End: 6

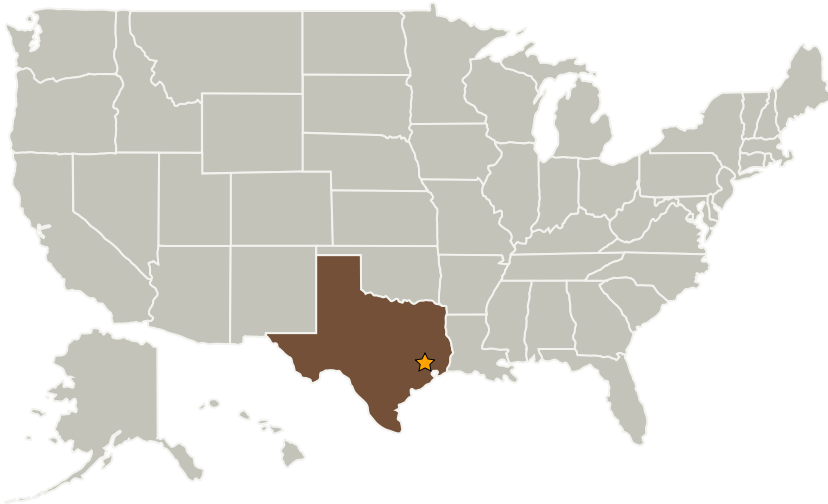


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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
University of Pennsylvania School of Medicine	Supporting Organization	Academia	Pennsylvania

Primary U.S. Work Locations

Texas

Project Transitions

**September 2010:** Project Start**April 2015:** Closed out**Closeout Summary:** We completed the study protocols with 34 participants with final report generated to NASA and future publications to be generated.

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
 - └ TX06.3 Human Health and Performance
 - └ TX06.3.3 Behavioral Health and Performance

Target Destinations

The Moon, Mars

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Stories

Articles in Peer-reviewed Journals
(<https://techport.nasa.gov/file/53336>)

Project Website:

<https://taskbook.nasaprs.com>